

The Department of Mechanical Engineering presents:

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11:10AM-12:00PM

Bourns Hall A265

## Does Nanotechnology Really Help, for Higher Thermal-Electrical Conversion Efficiency, in Thermoelectric Materials?

**Abstract:** The inter-conversion of thermal and electrical energy can be useful for many purposes such as waste heat recovery, body-heat powered biomedical devices, and temperature activated processes. Semiconductor materials exhibiting enhanced thermoelectric effects, such as the generation of voltage in response to a temperature gradient (the Seebeck effect) along with an optimized transduction of heat to electrical current, are especially suited for such applications. However, practically the thermal-electrical conversion efficiency had been quite low ( $< 6\%$ ). Much excitement was then generated when it was proposed that the use of lower dimensional nanostructures such as quantum wells and nanowires could considerably boost, by an order of magnitude, the traditional thermoelectric material efficiencies. This was sought to be accomplished through electrical carrier confinement effects which enhances the Seebeck coefficient ( $S$ ) and electrical conductivity ( $\sigma$ ). In this talk, I will propose the existence of an optimal  $S$  leading to the maximization of the thermoelectric power factor ( $S^2\sigma$ ) in any material, at any temperature and for any given dimensionality. It will then be shown, through a critical comparison of the magnitude of the density of states (DOS) of the bulk and nanostructured forms for a variety of materials, e.g., Si,  $\text{Bi}_2\text{Te}_3$ ,  $\text{PbTe}$ , and  $\text{Si}_{1-x}\text{Ge}_x$ , that there exists an optimal length scale only below which the  $S^2\sigma$  is enhanced over the bulk value. It is then concluded that it is the increase in magnitude, and *not* the change of shape, of the DOS as most responsible for the increase of the power factor and the thermoelectric figure of merit ( $ZT$ ). Our results lay the foundation for future research in the synthesis and characterization of nanostructured thermoelectric materials.

**Biography:** Prab Bandaru is an Associate Professor of Materials Science, in the Mechanical and Aerospace Engineering department, at UC, San Diego. After receiving his Ph.D. from UC, Berkeley, Bandaru worked in Applied Materials Inc., on non-volatile random access memories. He then worked as a postdoctoral fellow in the Electrical Engineering department at UCLA, on quantum computation. Dr. Bandaru then joined UC, San Diego as an Assistant Professor in 2003. His research group is mainly interested in materials physics and chemistry, broadly looking at the electrical, optical, thermal, and mechanical properties of materials at the mesoscopic and microscopic levels. Professor Bandaru has been recognized through various awards such as the Flint Seminar series lectureship in Applied Physics at Yale University, the Career grant from the National Science Foundation (NSF), and the Scientific American Top 50 scientists of 2006.

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